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ABSTRACT
                An important use of multimedia as a learning tool in
academia is the process of designing and developing a multimedia
project. The design and development process empowers students to
explore, discuss, evaluate, and articulate their knowledge in a
richer medium. A journalistic approach to examining the virtues,
limitations, and components of the multimedia process is proposed to
those new to multimedia or those still considering its value.
Formulating simple questions based on Who, What, When, Where, How,
and Why can provide a good starting point toward discussing issues
involved in the multimedia design and development process. A few
questions essential to examining the qualities of multimedia and its
development process are: Who should be involved?; What are essential
tools and guidelines?; When is the time and content appropriate?;
Where can you get help? Goals and objectives in the design and
development process include: (1) define what ideas, issues, and/or
concepts the project is intended to explore; (2) determine who your
audience is; (3) determine what resources are available for
developing as well as using the final project; (4) determine which
aspects of the design and development process each person involved
will have responsibility for; and (5) organize a schedule for each
stage and various tasks involved in each stage. The design process,
including using a flow diagram, gathering various media, and deciding
on an authoring program, is outlined. General guidelines are provided
on what to expect from various authoring programs and how to prepare
specific media material. Finally, the system and programming
environment for Ballot Box, multimedia software developed and used
for campaigns and elections, is examined. (Contains 37 references.)
(MAS)

Multimedia Design and Development
Who, What, When, Where, How and Why

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Those new to multimedia or those still considering its value will find it beneficial to take a journalistic approach to examining the virtues, limitations and components of the multimedia process. Formulating simple questions based on Who, What, When, Where, How and Why can provide a good starting point toward discussing issues involved in the multimedia design and development process. Who should be involved; what are essential tools and guidelines; when is the time and content appropriate; where can you get help, are a few questions essential to examining the qualities of multimedia and its development process.

What is multimedia? Perhaps this is the first question which needs to be asked. A quick glance into any dictionary might find a definition similar to the following. multimedia (multimedia , mul t ·) n. (used with a sing. v.)1. the combined use of several media, as films, video, music, etc. adj. 2. of, pertaining to, or involving the use of several media simultaneously. 3. having or offering the use of various communications or promotional media.

[1960 65]

multimedial adj.

For the purpose of this discussion of multimedia design and development the definition needs to be refined and extended as: pertaining to a computer mediated software program or document containing media such as text, audio, video, animation, and graphics combined or hyper linked and presented in a non-linear and interactive mode for the purpose of exploring one or more ideas.

The use of multimedia is increasing at a substantial rate in both the home and on college campuses as a tool for enhancing learning. Multimedia shifts the traditional learning paradigm of listening and researching to a more visual and interactive learning system. Multimedia supports the pedagogical model of student-centered learning where faculty are no longer the only resource but are simply another vital resource used to guide students in their learning experience. The use of multimedia, or any computer mediated learning, will never be a substitute or replacement for faculty. Computers don t teach or instruct; they allow students to explore and discover. Terms like Computer Based Instruction or Computer Aided Instruction are outdated and should be replaced with Computer Enhanced Learning. Unlike faculty, multimedia can not aid the student, for example, in evaluating the quality of information. Faculty serve as an invaluable and irreplaceable resource for guiding and advising students.

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An important use of multimedia as a learning tool in academia is the process of designing and developing a multimedia project. The process itself, rather than the resulting multimedia program or document, provides a new pedagogical tool for enhancing learning. A students search for knowledge understanding must involve more than just discovery and authentication. The multimedia design and development process empowers students to explore, discuss, evaluate, and articulate their knowledge in a richer medium. It provides students the opportunity to engineer and build their own knowledge base.

The multimedia process is changing the role of students and faculty. The distinction between teacher and learner is becoming less notable and less important. Student are able to enlighten one another as they collaborate together. Students expose faculty to new and different ways of expressing ideas and thus faculty stand to learn from the new knowledge base developed by students. As multimedia changes how the curriculum is taught it will inevitably change the shape and look of the content as well.

HOW?

It is difficult to imagine any discipline which can not make practical use of multimedia. The use of hypertext markup language (HTML) can be used to construct an integrated document based on connected themes in individual documents. The process of discovering relationships and links between various individual papers encourages collaboration. Students must closely examine and truly understand each paper and thus are exposed to other issues not focused on in their own paper. Therefore, the multimedia process is useful to any instructor willing to empower students to discover and explore independently as well as collaboratively.

Multimedia design and development requires time and energy. Designing and developing multimedia should be an activity which substitutes for another. If a course already involves a collaborative component then the multimedia process can be introduced to encourage collaborative work. In a course where students must write several papers on similar topics substitute the last paper with a collaborative exercise designed to create a large hypertext document in HTML which links related issues or ideas in a previous writing assignment. A course on medieval French culture, for example, could designate a portion of the semester to designing and developing a multimedia program which explores a day in the life a women in France during the 15th century. Students would collect or create images of people, city buildings and architecture, goods and produce, record dialog and create writings in French.

Multimedia serves the learning process best when more than one person is involved, but having too many people involved in one project can dilute its benefits. A large class of students should be grouped into teams to develop group projects. The most efficient and effective multimedia process involves a team composed of two to four people. Each person should be assigned to specific responsibilities. Every person in the team need not be involved in every aspect of the multimedia design and development process. Students can be assigned to various tasks such as leading the design stage, creating or acquiring textual, graphic, and audio material, and programming specific segments of the multimedia program or document. Assigning specific tasks to each student makes it easier to assess the quality of their work and involvement. Students learn essential skills required for collaborating as they learn to bring together their independent skills and responsibilities to support the goals and objectives of the team. As students lead and push one another they learn they must accept accountability for success or failure.

As students acquire new skills and knowledge to contribute to the project they become a resource to one another. Students should be encouraged to share their skills and knowledge with other team members. Peer-to-Peer teaching foster a collaborative learning environment and allows students the opportunity to extend beyond the role of learner and occasionaly become the teacher as well.

When is the time or content right for the use of multimedia and its process? The content should be an idea to be explored, examined, and open to interpretation and not simply expounded upon. The idea must lend itself well to multimedia and demand the use of multimedia in order to be presented fully and effectively . An idea which can not stand on its own with pure text, which not can not otherwise be completely conveyed without the use of pictures, sound, video, or animation, is appropriate content for multimedia. When the content is appropriate then the time is appropriate.

Getting support for the use of multimedia relies on its success. To insure success keep the multimedia process simple. To keep the process simple keep the project simple. Avoid using unnecessary media and be careful not to overuse any paticular medium. Keep focused on the goals and objectives of the idea. Remember, the use of multimedia is not the goal but rather the tool for expressing an idea. Design your project to allow free exploration by allowing the viewer to navigate along multiple paths through the media. The key is to be flexible and responsive to different learning styles.

Start off small and build on previous successes. It is important that the use of multimedia be focused on courses which have the most to benefit from its use. Courses in the natural sciences are always good candidates for multimedia as a means of illustrating difficult or abstract concepts not readily apparent to the naked eye. Interdisciplinary courses have much to gain as well as much to draw from when using multimedia. The inherent nature of multimedia to combine text, graphics, audio, video, or animation can provide an eloquent method for exploring the relationship of one or more ideas across disciplines.

Once the project is completed share it with the community. Demonstrating various multimedia programs or documents allows the academic community to assess the value of using multimedia to enhance learning. Demonstrations can help build support for the continued use of multimedia and provoke other faculty to consider the value of multimedia in their own courses. Provide opportunites for colleagues and senior administrators to see and understand the importance of the multimedia design and development process as a new teaching tool and its pedagogical importance. Early adopters of multimedia can serve as mentors to other faculty getting started.

With an understanding of what multimedia is, how it can be used, when to use it, and why, it is time to get started. The implementaior of the multimedia process begins with an idea, but having a great idea is not enough to get started and succeed. You need to have the appropriate microcomputer and equipment to support the design and development of a multimedia project. The typical multimedia development system is often something more powerful and better equipped than the system upon which the finished project is intended to run on. The typical development system would be based on a 66mHz processor, 1 gigabyte hard drive, 16 megabytes of RAM, a VGA monitor with a resolution of 640x480 (512x342 Macintosh), 8 bit sound card, video capture card capable of capturing video at 15frames/second at 320x240 pixel resolution, and a color scanner capable of scanning images 1/4 to 1/2 the size of the screen display with up to 256 colors.

The 66mHz processor provides the speed and performance to work comfortably while manipulating multimedia material, as well as providing the speed to support the video capture. The specification of VGA video may seem mistaken considering all new systems are well equipped to handle 1024x768 at 256 colors and perhaps even higher resolutions. But a successful project shouldn t require an older system to be upgraded. If a system doesn t have the capability to display at least 640x480 with 256 colors then it most likely isn t intended to be used for multimedia. The key here is to design and develop for the lowest common denominator; the microcomputer most likely to be found on the college campus. In addition the 8 bit sound and 320x240x256 15 frames/second video should perform sufficiently on these type of machines. Also, you should be prepared to demonstrate your program by having it projected on a large screen in front of an audience. Again, plan for the lowest common denominator, which would be a color LCD plate used with an overhead projector. Currently, LCD plates can display and project a maximum resolution of 640x480. If your multimedia project is designed to display at a higher resolution the LCD plate will not be able to display the full screen. If important material or controls are located in the non-displayable area of the screen then the impact of your demonstration is compromised and interaction is limited or disabled.

Designing and developing a multimedia project that exceeds these criteria limits the number of microcomputers on which it can be used, and this in effect may reduce its usefulness. Though the design and development process is, pedagogically, the most critical consideration the function and practicality of the final product is crucial as well.

Only two or more media need be present to establish a multimedia program or document. It is crucial that only those media are used which are essential to the idea being explored. The program or document must allow the associations between related ideas or concepts to be virtually linked together by controls so as to allow it to be interactive and navigatable in any direction. Links which allow nonlinear navigation and interactive exploration allow the program or document to be responsive to different learning styles. If the program or document does not allow interaction then it defeats the purpose of exploratory learning. The ultimate goal of any multimedia program or document should be to enhance learning through exploration.

The two major efforts for any multimedia project are the design and development stages, and obviously the design stage comes before the development stage. But before even beginning the design stage it is important to develop a few goals and objectives for the design and development stages. The goals and objectives can be summarized as:

1. Define what ideas, issues, and/or concepts the project is intended to explore.
2. Determine who your audience will be.
3. Determine what resources are available for developing as well as using the final project.
4. Determine which aspects of the design and development process each person involved will have responsibility for.
5. Organize a schedule for each stage and various tasks involved in each stage.

It is important to write down your goals and objectives and have them easily visible throughout your project so that you can refer to them frequently.

Begin by summarizing in one or two sentences the ideas, issues, and/or concepts you wish to explore. This summary can be developed in several sentences which define or illustrate what the ideas, issues, and/or concepts are. In addition, identify how these ideas, issues, or concepts might be presented or dealt with in the program or document. Your summary should be the corner stone of your project and something you refer back to frequently during the design and development stage to insure that you stay focused.

The next step is to identify and understand your intended audience as precisely as possible. The keyword here is intended. Trying to design a multimedia program or document to meet the needs of everyone can be a mistake. Narrowing your focus on a specific audience will help to steamline the development process. Knowing that your program or document is intended for first year biology students interested in exploring the fundamental concepts involved in the process of photosynthesis dictates a different look and feel from one intended for upper level chemistry students who need to explore the biochemical processes involved in photosynthesis.

Next, determine what resources you will need and which of these will be available for your project. The resources you need will be determined by the various media you plan to use. Using text is the easiest medium to use. The degree of complexity in dealing with various media increases as you to begin to include graphics, audio, animation, and video respectively. Identify what sofware programs; such as for authoring, audio and video digitizing, animation, graphic design, and associated equipment you will need and how each will be used. The quality of the software for creating and manipulating various media effects has a significant effect on how easily the various media will be to implement in your project. If any items of software or equipment are not available or inappropriate for your needs then you must be prepared to make adjustments in order to accommodate the goals and objectives.

At this point you should have a pretty good idea of what is going to be involved in your project and can therefore begin to assign various parts of the design and development stages to those participating in the project. There are two approaches you might take to assigning tasks. You can identify which individuals are best suited to a task and assign each task accordingly. Or, you can do the opposite and provide an opportunity for participants to build skills and knowledge from new experiences. Keep in mind that the latter approach can impact the time in which the project is completed and perhaps the quality of the overall project. Therefore it is important to determine what is most important about the project: the learning experience it provides or the final multimedia program or document.

Finally, organize a schedule which provides specific details as to when the various tasks are to be completed. Determine which tasks need to be started or completed before others. Carefully determine how long each task will take. If time permits, allow yourself to be generous with the amount of time required for various tasks. Keep in mind that you can t expect everything to go smoothly, and be prepared to run into a few snags. It is difficult to anticipate each and every detail so don t try. Be prepared to compromise or eliminate components deemed less important if you become pressed for time.

Designing

With your goals and objectives clearly identified and written down you are ready to begin the design stage. The design stage is arguably where the majority of the work is done. The design stage involves creating a flow diagram which illustrates how your multimedia program or document will be

constructed. Time well spent creating a flow diagram minimizes time spent later making changes. A typical flow diagram might look like this:

Begin by using pencil (you ll need an eraser too) and paper to draw symbols which illustrate various components of your program or document. The various components include text graphics, audio, video, animation, and buttons for navigation; such as CONTINUE, BACK, RETURN to MENU, HELP, EXIT, which provide the means for interaction. Keep in mind the flow diagram does not show the actual text, graphics, sound, etc., and instead it shows symbols which represent these components. The flow diagram illustrates the relationship between the various component, how components act upon or respond to one another and what type of transition effects you will use (i.e. fading, sliding, dissolving images). It is important to allow the person viewing your prog .m or document to follow any one of multiple paths through your program or document. Multiple paths allow unrestricted exploration and the ability to focus on specific areas important to the user. Be prepared for your flow diagram to be a series of a dozen or more sheets of paper taped together, some top to bottom and some side to side, which illustrate an expansive web-like structure. Each symbol must be identified and annotated as to its purpose and function. A portion of a flow diagram might look like this:

The flow diagram is crucial in its illustration of now all the controls and media components function together. A clear illustration allows you to move into the development stage knowing exactly what sequence these components will be laid out with your multimedia authoring program.

Another step of the design stage is the gathering of your various media. This will involve creating original works in the form of text, pictures, music, voice, video, and animation. If you need to use materials which already exists be sure to get appropriate permission so as not to violate any copyright laws. It is important to have all your materials ready in their digital or electronic format before continuing to the development stage.

It would be best to decide at this point what multimedia authoring program you want to use. Your decision should be based partly on whether or not the authoring program can accept the types of media you want to use. It is best to let the content and media in your program or document influence your decision on what authoring program to use rather than letting the authoring program dictate what media you can use. It can be rather easy to implement a multimedia project using Microsoft Word or WordPerfect. These two word processors provide the capability of imbedding images, sound, video, and hypertext. Some slide presentation programs, such as Microsoft PowerPoint, also offer the capability to play back sound and video. HTML is a very popular way to present hyper linked multimedia documents on the Internet as well as linking documents stored locally. Any software program that provides these capabilities may be a suitable platform for authoring a multimedia project. A few of the mos. common multimedia authoring programs to date are Asymetrix Multimedia Toolbook, HyperCard, Macromedia Authorware Professional, Authorware Academic, Macromedia Director, SuperCard, and HTML Assistant.

Development

When planning the types and quality of media to use in your program or document it is important to know what your authoring program will or won t allow you to do. The following are some general

guidelines for what to expect from most authoring programs and how to prepare specific media material.

Text can easily be entered directly into your project usi..g ...t. .ols built into most authoring programs. Ii you want to create your text with a word processor (WordPerfect, Microsoft Word, etc.) you will need to convert your document to ASCII text before pulling it into your multimedia program or document. Some authoring programs will recognize Rich Text Format (.RTF) files. These files can be moved from a word processor to the authoring program and still retain many of the text formatting attributes (boldface, underline, indenting, fonts, etc.). Plan on formatting your text (boldface, underline, italics, etc.) from within the authoring program once it is in place.

Simple graphics can be designed with built-in graphic tools or those included as a separate program. If you want to create your graphics with a more sophisticated graphic design/paint program be sure that it can be saved to a format that the authoring program will recognize. Most authoring programs will recognize Bit mapped (.BMP), Tagged Image Format (.TIF), General Interlaced Format (.GIF), or .PICT format (Macintosh Picture). Use an optical scanner for digitizing existing still images. Limit images to 8-bit color depth (256 colors) if possible. More colors require more advanced equipment, more storage space, and a faster video system. Limit image size to no more than 1/4 - _ the size of the screen display. Single images displayed using the full screen are less effective than those of a smaller size and accompanied by text which might explain the use of the image.

Most authoring programs don t provide any built-in method of capturing audio and converting it (digitizing) to a file on disk, so a separate audio digitizing program will be required. Most authoring programs will accept either MIDI (Musical Instrument Digital Interface), .WAV, AIFF or System 7 (Macintosh). You should be able to digitize sound from audio tape, compact discs, microphone, or anything else that plays sound and can be connected directly to the sound recording device in your multimedia development system. Limit audio quality to 8-bit resolution at Radio or Tape frequency. Use CD quality sound sparingly since every 10 seconds of CD quality sound requires nearly _ megabyte of storage space.

- 8-bit resolution (256 sound levels)
- Radio : sampled at 11kHz
  = 11,000 times/second
  = 11,000 bytes/second
- Tape : sampled at 22kHz
  = 22,000 times/second
  = 22,000 bytes/second
- CD : sampled at 44kHz
  = 44,000 times/second
  = 44,000 bytes/second

The ability to display and overlay live video in your multimedia program or document from a laserdisc is common in most authoring programs. Your program or document will be able to communicate with

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a laserdisc using control statements for playing, pausing, reversing, forwarding, stopping, and quickly locating the next video selection. But if you lack a laserdisc player you will need to capture your video and digitize it. The digitized file can then be loaded directly into your multimedia program or document. Video capture and digitizing is a feature not often found as part of most authoring programs, so a separate video digitizing program will be required. Most authoring programs will accept either AVI (Audio-Video Interleave), or QT (QuickTime) video files. You should be able to digitize video from a video cassette recorder (VCR), video cameral (camcorder), television, compact discs, microphone, or anything that plays video and that can be plugged directly into the video capture card in your multimedia development system. Limit video quality to no more than 24-bit color depth at 160x120 or 320x240 resolution (pixel width x height) and 15 frames/second. Typically, you will need 3.5 megabyte of storage space for every second of video captured.

- 24-bit color depth (16,777,216 colors)
- 30 frames/second = television frame rate
- 24 frames/second = motion movie picture frame rate

Video Size in bytes = (pixels wide x pixels high) x color depth (Bytes) x frames/second

Example: 320 pixels x 240 pixels x 3 Bytes (24-bits) = 230,800 Bytes/Frame

    230,800 Bytes/Frame x 15 Frames/Second = 3,456,000 Bytes/Seconds

Most video capture cards come with software used to compress video so that it won t take up so much space. The playback quality will be degraded slightly, but it is possible for a 70 megabyte file to be compressed to 9 megabytes.

Simple Animation tools are provided in most authoring programs. Simple animations consist of moving one or more objects across the screen along a predetermined path. To develop animations with more detailed movement requires a separate animation program. Common animation formats are Autodesk Animator Flic files (.FLC, .FLI) and Macromedia Director movies (.DIR, .MOV, .MMM). Treat the use of animation like video. The more complex the animation the more disk space and computing power it requires to make it run smoothly.

Managing all of the acquired media in their electronic format will most likely exceed your storage resour within a short period of time. It is advisable to store graphics, sound, video, and animation files on an external storage device such as a large capacity disk cartridge. Reputable vendors such as Iomega and Syquest manufacture removeable disk cartridges which can hold, presently, up to 230 and 270 megabytes of data per cartridge, respectively. The cartridge drives themselves cost approximately $500. The cartridges, depending on the size, manufacture and vendor, cost $70 to $100. These cartridges can be issued to students for storing their work. With materials isolated on these cartridges, the possibility of the material being inadvertently damaged or deleted by another students is minimized.

So what equipment can you expect others to have to view your program or document and what equipment will you need to put your project together? You should plan on sound and video playback being available. Most systems come with or have available to them software for playing sound and video which does not require the expense of additional hardware. Keep the sound and video quality as low as possible without sacrificing too much. There isn t much point in providing CD quality sound if

it will be played back on $30 speakers. And there isn t much point in trying to digitize your video at a 24 frames/second if it will be played back on a system that can barely keep up with 15 frames/second. The key here is to design and develop for the lowest common denominator.

Getting help with designing and developing a multimedia program or document may not necessarily always come from the folks in technical support who are responsible for the authoring program you are using. If you have access to the Internet you will find plenty of help available for every aspect of multimedia design and development. Among the many resources on the Internet are Listservs for discussing many of the popular multimedia authoring programs as well as graphic, audio, video, and animation programs. In addition, you can find many software libraries with demonstration, utility, and example programs for the beginner as well as the advanced multimedia developer. Some valuable starting points for multimedia information from the Internet are located on the World Wide Web at the following sites:

http://hakatai.mcli.dist.maricopa.edu/authoring/mm.html

http://viswiz.gmd.de/MultimediaInfo/

http://akebono.stanford.edu/yahoo/Computers/Multimedia/

http://www.firmware.com.au/

As information technology explodes into the twenty-first century students not only need to be proficient users of new information access tools, but they must also be able to capitalize on new and effective tools for learning and communication. It is apparent that multimedia offers a new means for engaging students and enriching their learning experience by allowing them to become more intimately involved as creators of their own knowledge base. The multimedia design and development process accommodates and fosters many different learning styles which are often restricted by the traditional lecture or seminar style of teaching. Focusing on the multimedia process rather that the product eliminates the concern for, and distractions of, the technical issues and allows the student and instructor to continue concentrating on the course goals and objectives. Multimedia and the design and development process offer new opportunities for effective learning and communication.

ilable to us has improved, we have made significant changes to our system. First, we were able to scan in and present still pictures of each of our candidates. These pictures were digitized and presented as bitmaps using Toolbook's ability to show both graphic images and text. Then, with the release of Multimedia Toolbook 3.0 and its greatly enhanced capacity to handle digital video, last summer we enhanced the system again to include video campaign ads, as well as our standard text-based information. Thus, the system has truly become a multimedia system, incorporating text, still pictures, video, and audio into a single simulation.

As subjects go through the primary campaign, choosing information of interest, they are interrupted from time to time by the campaign videos, which overlay the label boxes, and temporarily disable the ability to examine text-based information. Thus, subjects have little choice but to watch the videos. When an ad finishes, the label screen reappears. After a preset period of time, the primary election ends, and subjects must vote for their preferred candidate. At that point, the general election begins, featuring one candidate from each party. Subjects may or may not see the candidate they chose in the primary

end up in the general election -- in other words, sometimes they vote for "winners," other times for "losers." The general election is basically the same as the primary, with video, text, and pictures available. At the end of the general election, subjects make a choice between the two candidates and then end the simulation. Finally, some information is collec! ted via a pencil and paper questionnaire.

The System and Programming Environment for Ballot Box

While the presentation to the user of the system is reasonably straightforward, and appears relatively simple, the programming environment is actually quite complex. The original system was designed using Apple Hypercard, and ran on Macintosh machines. In 1991, we began converting it to Toolbook 1.5, for two basic reasons. First, we wanted to make full use of color, and color Macintosh's were relatively rare. Second, Rutgers political science had standardized on Intel-based machines. Conversion was relatively straightforward, and we began running experiments with it in 1992. As the technology improved, and available PC's became more powerful, we took advantage of new capabilities and the system grew more complex. With the arrival of Toolbook 3.0, both power and complexity increased again. In 1995, we are running the Ballot Box system under Toolbook 3.0a, in a Windows for Workgroups 3.11 environment. We acquired two IBM Thinkpad 750Cs portable computers in order to take the experiment into the field, rather than requiring subjects to come to our offices. These computers have 80486 DX33 processors, 8 Mb RAM, and 340Mb hard drives. The Thinkpads come standard with sound chips, eliminating the need for any kind of external sound device in order to play the videos. While they also possess good quality screens, we needed to present the simulation on relatively large screens, to make using the system easier for subjects. So along with the portable computers, we added two 15 inch external monitors by NEC. Each portable computer was configured in exactly the same way, so that there would be no variations in the way the system ran on either machine. The machines were also equipped with docking stations and ethernet adapters so that when returned to the office, ! all data on them could be accessed across our office Windows for Workgroups based network.

Because of the addition of video to our system, we needed to acquire a system powerful enough to produce and edit videos. We chose an 80486 DX2/66 machine initially, which has since been replaced with a Pentium-90 machine. This video production system has 32Mb RAM, nearly 2 gigabytes of fast hard disk space. It has been equipped with an Intel Smart Video Recorder card for video capture, along with a Soundblaster 16ASP card for audio capture and playback. We are using Adobe Premiere 4.0 to capture segments from videotape and create our own digital campaign ads. Voice overs are then added to the video and a complete 20-25 second campaign ad is produced and compressed. Even with compression, though, the campaign ads take up to 3Mb of disk space for each ad. Working with Toolbook means learning object-oriented programming (OOP). For programmers used to the more traditional languages like COBOL or BASIC, OOP based languages can be very confusing. Toolbook functions under a hierarchical structure. Messages are sent from the level at which they occur on up the structure until a script is found to handle that message. Clicking a button sends a BUTTON UP message to the script for that button. If there is no BUTTON UP handler defined for the button, the PAGE that the button is on will get the message. If it has no BUTTON UP handler, the message will be sent up to the BACKGROUND level, and so on, until a handler is found or an error generated. Every object that is

defined on a screen can have a script associated with it. If there is a script, that script will define the events that occur when the user selects that object. If there is no script, the object is generally simply a graphic or a field into which data can be typed. ! It is the interaction of the scripts, and the messages that get sent through the hierarchy that define how the application operates.

Scripts are programmed in Toolbook using a language called Openscript. Openscript is very English-like in its syntax and use. It may remind programmers of BASIC in its simplicity. However, that simplicity masks a great deal of very powerful function. Openscript has a wide range of pre-defined functions which, when built into a script, allow for the complete control of every object on the screen. As will be seen in the examples below, Openscript is structured, and programming in it is a good test of the ability to master structured programming techniques. This structure is critical to Openscript, as there is no GOTO construct. Everything must be managed through looping structures, calling structures and through the hierarchy of objects. Perhaps one of the biggest culture-shocks for traditional programmers who face an OOP language is that there is no one place in which you can see the complete flow of the program, since the program does not have any kind of typical top to bottom flow. Instead, objects are identified and grouped together as needed. Scripts are defined for each object only once, and then re-used at an appropriate place in the application's hierarchy. Consequently, trying to see the big picture of an application can be difficult. Added to this is the fact that Toolbook does not have any way to print out all of the scripts associated with an application in one pass. Also, the data associated with an application is stored in a special format, within fields that are themselves objects. So, while it is very easy to manipulate the data from within a particular application, creating large amounts of text is better done outside of the application with a word processor. The text can then be imp! orted into the application and placed into appropriate fields.

The strength of Openscript and Toolbook is the ease with which it handles graphical objects and video. Candidate pictures in Ballot Box are bitmaps, which are stored on disk outside of the Ballot Box application. When a subject access a picture, the Openscript programming merely reads the bitmap in and plac₋₋ it on a predefined "stage" on the screen. This works very quickly, and provides incredible flexibility. For example, if we wish to vary the pictures of our candidates, while holding constant all other information, this is easily coded. Multimedia objects, such as videos, are handled in a similar way. Toolbook contains a number of functions which open, play, rewind, and close digital video and digital audio. Coding these objects is simply a matter of placing a pointer to the disk file and reading it.

Future Directions

We have now used our simulation to run six sets of experiments, though we have so far analyzed data from only three of them. (See Lau and Redlawsk, 1992; Lau and Redlawsk, forthcoming; Redlawsk and Lau, 1995 for reports of the data analyses.) Our studies have included manipulation where we have varied the number of candidates in the primary election -- so that some subjects got two candidates in their party and others got four -- as well as varying whether or not the preferred primary candidate becomes the general election candidate; that is, whether the candidate for whom the subject voted in the primary win the nomination. We have also varied the number and content of the campaign videos that are shown. as well as changed the gender of candidates. In our next study, to go into the field this month, we are varying the attractiveness of the candidates, to assess how personal factors influence the way people process political information. From the standpoint of our system, we have some plans for

change. The campaign videos were currently use are very rough -- their quality is not as good as we would like. In addition, because we chose to use Microsoft's Video for Windows, and our portables do not have local bus graphics, we have been limited to running the videos in very small windows. Our plans include upgrading our equipment so that the videos can run in at least a 240 X 320 window. Further, as video capture technology improves, we expect to be able to get better images in our videos. The recent upgrade of our video production machine gives us a platform to improve this critical are of our application. Finally, the Ballot Box program is not unlike many programs that have been developed and changed over time. It contains code that is no longer used, as well as inefficient structures that need to be streamlined. Most importantly, for our purposes, we hope to simplify the system so that any researcher interested in similar questions would be able to use the program without the necessity of recoding large amounts of the system. For the kinds of questions were are asking in our research program, Rick Lau and I needed to have a methodology that is radically different from that employed by most political scientists most of the time. Thus, we borrowed the information board concept from psychology and consumer behavior studies. We then changed its very nature by making our system dynamic, where we could match the flow of campaign information over time, in order to understand how information affects the voting decisions that people make. We see this technology as continuing to support our research, as we find additional ways to apply it over time.

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